Flora W. Patterson

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The Brown Rot of Peaches, Plums and Other Fruits.

(*Monilia fructigena Persoon.*)

By A. L. QUAINTANCE.

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CONTENTS.

	PAGE
General Remarks	237
The Weather	238
Loss from Brown Rot	242
Distribution and Economic History	246
Host Plants	247
The Appearance of Brown Rot	247
The Disease on the Flowers	247
Blighting of the Twigs	247
Rotting of the Fruit	249
Keeping Qualities of Peaches Enhanced by Spraying	250
Susceptibility of Different Varieties	251
The Brown Rot Fungus	252
Synonomy	252
Relationships	252
The Spore	254
The Mycelium	257
Brown Rot in the Orchards	258
Where the Winter is Passed	259
Spraying for Brown Rot	259
The Proper Formula for Bordeaux	264
The Preparation of Bordeaux Mixture	265
Copper Acetate	266
How Many Times and When to Spray	266
The Cost and Benefits of Spraying	269

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THE BROWN ROT OF PEACHES, PLUMS AND OTHER FRUITS.

(*Monilia fructigena* Persoon.)

GENERAL REMARKS.

Probably not in the history of commercial peach and plum growing in Georgia has there been such serious loss from Brown Rot as occurred this year. While there is, every fruit year, more or less of rot, it is only under exceptional weather conditions, such as have been experienced the past season, that this disease assumes such importance as a factor in determining the financial outcome of a crop. The period of danger from late spring frosts having been safely passed, there was much reason to expect, in the usual course of things, a large crop of fruit of the usual high character and quality. But, beginning about June 1st, there followed a month or six weeks of rainy and more or less cloudy weather, which not only greatly favored the rapid growth and spread of the Brown Rot disease, but put the fruit in condition to become more readily infested. Many of these rains were quite light, but served to keep the air humid and the fruit more or less moist. Others were quite heavy and the ground was thereby thoroughly wet. The rains served to induce a vigorous growth of wood, and to cause fruit to become watery and tender. Under these very favorable weather conditions to the disease, the relatively small amount of the Brown Rot fungus, usually present in orchards, developed and spread with great rapidity. The fruit, as it begins to ripen, is probably most readily infested, and whenever such conditions prevail—that is, heat and moisture at or near the ripening period of the fruit—serious loss from Brown Rot is more than likely to occur. More specifically, in Georgia, a "wet June" is likely to be followed by serious rotting of fruit. It is a frequent statement that the rotting of fruit is due to rainy weather. This is true only in the sense that such weather conditions are favorable to the growth and spread of the fungus causing Brown Rot. Although excessive rains might occur, there could be no Brown

Rot on the fruit unless the Brown Rot fungus, *Monilia fructigena*, the specific cause of the disease, were present.

THE WEATHER.

It is a matter of general observation that when the rainfall, during any considerable period of the growing season, exceeds somewhat the normal, unusual losses of crops from various blights, mildews and rusts are likely to result. Parasitic fungi, in general, undoubtedly do thrive best during moist or rainy weather, and the effect of the temperature, considered in connection with the humidity of the air and precipitation, is quite marked. In the case of a disease like Brown Rot, whose seriousness depends largely on abnormal weather conditions, as excessive rainfall or humidity, it is instructive to compare the weather conditions which prevailed from March to August of the years 1898 and 1900.

The fruit crop of 1898 was, in most sections of the State, a full one, and the loss from Brown Rot not unusually large. The crop of 1900, in point of prospects, was equally large, if not larger, and the rotting was excessive. The following table, compiled from Director Marbury's Climate and Crop Service Reports, will serve to show the difference in the mean monthly temperature and average precipitation for the first six months of the growing season of these two years.

TABLE I.

MEAN MONTHLY TEMPERATURE AND AVERAGE PRECIPITATION, WITH VARIATIONS FROM THE NORMAL, FROM MARCH TO AUGUST OF THE YEARS 1898 AND 1900.

MONTHS.	1898				1900			
	Mean Monthly Temperature.	Variation from Normal.	Average Precipitation—inches.	Variation from Normal—inches.	Mean Monthly Temperature.	Variation from Normal.	Average Precipitation—inches.	Variation from Normal—inches.
March	61.	+4.5	2 82	—2.22	53.2	—2.7	5.43	0.0
April	59.4	—5.	4.49	+1.16	64 3	—0.5	5.72	+2.36
May	74.	+3.1	1.12	—1 93	70.8	—0.2	2.46	—0.82
June	80 1	+2.2	3.27	—1.43	75.6	—1.9	8.98	+4.58
July	79.8	—0 2	8.14	+2.32	80.3	+0.5	5.12	—0 63
August	78.5	— 0.3	10.09	+4 66	82 3	+3 6	2 55	—3 10

In point of temperature, it is to be noted that in 1898 the month of March was considerably above the normal, while during April it was one-half degree more below. During May and June, the temperature is registered as above the normal, and in July and August, slightly below. In 1900, from March to June, the temperature is seen to have been below the normal, with July slightly above, and August considerably so. Comparing the month of June, of the two years, there is seen to have been a difference of 4.1 degrees in the mean temperature. In May, of the two years, the difference in mean temperature was 3.3 degrees, and in July only 0.7 degree.

The total average rainfall, from March to August of 1898, was 29.93 inches; and for the same period in 1900, 30.36 inches. The amount of rainfall for each of the two periods mentioned is therefore practically the same; but a consideration of the average monthly precipitation of the respective months shows considerable difference. Thus, in June of 1898, the precipitation was 1.43 inches below the normal, while in 1900, for the same period, it was 4.58 inches above, making a difference in rainfall, for the respective periods, of 5.75 inches. May, of both years, fell below the normal, while April, of both years, was above. Beginning with July of 1898, the precipitation was 2.32 inches above normal, and in August, 4.66 inches above. In 1900 the reverse occurred, showing for July a deficiency of 0.63 inch, and for August, 3.10 inches. In 1898, during the months of March, April, May and June, the sum of the deficiency for these months is 4.42 inches. During the same months in 1900, the sum of the precipitation above the normal is 6.12 inches, making a total difference in the rainfall of these two periods of 10.54 inches. During July and August of 1898, the excess of rain was 6.98 inches, and during the same period in 1900 there was a deficiency of 3.73 inches.

Considering the month of June, 1900, more in detail, Director Marbury's report may be quoted in part: "Practically the entire month was rainy; at many stations rain fell on from twenty to twenty-five days; at some stations there was not a single clear day during the month, and the average number of the clear days for the State was but one. * * * * * * * * * * *

"The temperature averaged a departure below the normal of two degrees, making the coolest June, with one exception, 1893, in the past nine years. The maximum temperature for the State, 99, was the lowest, and the minimum, 53, the highest since 1892. The relative

humidity was very high, and the wind movement low, and the daily ranges and changes in daily mean temperature small."

The following table will show more exactly the weather conditions during June at several stations located in or near some of the larger fruit growing sections of the State:

TABLE No. II.

JUNE WEATHER AT STATIONS IN OR NEAR SOME OF THE LARGER FRUIT GROWING REGIONS OF THE STATE.

LOCATIONS.	County.	Altitude in feet.	Temperature. Degrees Fahr.			Precipitation in Inches.			Number of rainy days.
			Mean.	Departure from normal.	Greatest daily range	Total.	Departure from normal.	Greatest in 24 hours.	
Adairsville	Bartow	772	74.6	—1.5	23	10 76	+7.75	1.98	21
Atlanta	Fulton	1174	74.1	—0 9	24	8.96	+4.74	2 34	19
Gainesville	Hall	1254	71 8	—2 7	20	12.09	+7.42	2 10	20
Rome	Floyd	576	75 2	—0 6	28	9.92	------	1.50	18
Augusta	Richmond	134	77.2	—2.0	21	8 25	+3.62	1.39	18
Dublin	Laurens	----	----	------	------	9 28	------	2.43	10
Experiment	Spalding	1000	74 5	------	24	12.02	------	4 27	19
Macon	Bibb	334	76.6	0.0	22	6 69	+2.27	1.96	19
Marshallville,	Macon	491	78.8	—1.3	22	4.38	+0.75	0.95	16
Albany	Dougherty	232	80.8	—0.4	25	8.24	+1.83	2.37	14
Fitzgerald	Irwin	515	79 0	------	34	3.39	------	0.55	18
Poulan	Worth	365	77.7	—1 4	24	4.19	—0 31	0 75	18
Thomasville	Thomas	330	79.0	—0.4	22	11.84	+6.96	2.97	14

FIGURE 1.

The Brown Rot on Alexander Peaches, showing spore-tufts, or "mold."

LOSS FROM BROWN ROT.

Shortly after the shipping season of peaches was over, the following letter was mailed to a number of the larger orchardists, to determine, in connection with other data, the approximate losses sustained from this disease:

EXPERIMENT, GA., Aug. 20, 1900.

DEAR SIR: The unusually rainy weather of June and early July of this year furnished very favorable conditions for the development and spread of the brown rot of peaches and plums. As a result the loss of fruit to many growers has been very heavy, not only on the trees, but after having been picked and shipped to market. Heretofore, losses from this disease in Georgia have been comparatively light, and orchardists have not, as a rule, made a practice of spraying as a preventive. In view of the losses of the past season, in the rotting of peaches and plums, it seems desirable that there should be a better understanding of this disease and how it may be controlled, so that losses in the future may be reduced to the minimum. Preliminary to the preparation of a bulletin on the subject, in order that the report may be as comprehensive as possible, I wish to obtain certain data relative to the disease. As this is a matter which deeply concerns growers of peaches and plums, it is hoped that those interested will co-operate by giving their observations and experiences with this brown rot disease. To facilitate the matter, the subjoined topics are given, indicating the points about which information is particularly desired:

(1). An approximate estimate of the per cent. of peaches and plums which has rotted this year in your own orchards, or in those of your locality.
(2). Varieties which have rotted worst.
(3). General weather conditions during May, June and July.
(4). Approximate date of first appearance of rot.
(5). Treatment for rot, if any.
(6). The fungicide used, strength and date of application.
(7). The effect on foliage, if any.
(8). Value of treatment in preventing rot.
(9). The loss to you from rot, approximately in dollars and cents.

Respectfully yours,

(Signed.) A. L. QUAINTANCE.

From the replies received from this letter, and from inquiry in person, considerable information was secured, a part of which, particularly that relating to the per cent. of rot in the different sections of the State, is here presented in brief.

In the orchards of the Hale Georgia Orchard Company, at Fort Valley, comprising some 236,000 bearing trees, the loss from rot on the trees is stated to have been approximately thirty-three and one-third per cent. Instead of an estimated shipment of 200 cars, but 130

were shipped. Japan plums rotted from fifty to seventy per cent. No spraying was done, but the rotten fruit was regularly collected.

In the orchards of Maj. Jones, Fort Valley, the amount of rot was estimated at thirty-three and one-third per cent., and an equal per cent. was lost enroute to market in the cars. The varieties mostly grown by Major Jones are Tillotson, Family Favorite, Belle and Elberta.

Mr. C. W. Wright, also of Fort Valley, estimates the amount of rot in his orchards as averaging twenty-five per cent., and a like per cent. was lost in transit to market. Of the Elbertas, about fifty per cent. rotted on the trees in blocks that had been well fertilized and cultivated. On new ground Carman rotted about forty per cent., while on old ground, where the trees were less vigorous, but little rotting was noticed. Likewise, Early Rivers, on new ground, rotted from twenty-five to forty per cent., while on old ground the fruit was remarkably perfect.

At Marshallville, Mr. Nash Murph estimates the amount of rot in his orchard of 30,000 trees at thirty-three per cent. on most varieties, while with some the loss was quite fifty per. cent. Curiously enough, in the neighboring orchard of Mr. W. S. Sheppard, likewise unsprayed, the per cent of rot is stated to have been very small.

In Mr. S. H. Rumph's orchard of 140,000 bearing trees, Mr. Rumph states that there has been practically no rotting of the fruit, and he attributes this freedom solely to the fact that his trees were systematically sprayed with Bordeaux Mixture. His principal varieties of peaches are Early Michigan, Belle, Elberta and Emma; and of plums, Red Nagate, Botan and Burbank. Likewise, Mr. E. J. Willingham, whose orchard is located at Marshallville, has, by a systematic use of Bordeaux Mixture, been able to practically prevent loss from Brown Rot.

At Loraine, (Mims) Bibb county, the rot has been quite severe. Thus in the case of the Nesbitt orchard, where two cars were expected, only 150 crates were shipped, and these mostly rotted enroute to market. In the Callaway orchard of Elbertas, instead of the expected six cars, but two were shipped, and these were mostly rotten when their destination was reached.

Notwithstanding the seriousness of the Brown Rot in this locality, Mr. J. D. Howard experienced a considerable freedom from rot, and he attributes this to the effect of two applications of Bordeaux Mixture.

Major G. M. Ryals, whose orchard is at Ty-Ty, was also quite successful in preventing serious loss from Brown Rot by the use of Bordeaux, and he is an earnest advocate of the use of this fungicide for the control of this disease. The success of Messrs. Rumph, Willingham, Howard and Ryals, in the control of Brown Rot in some of our largest commercial orchards, clearly indicates the practicability of effecting spraying on a large scale. A more detailed account of the experience of these gentlemen will be given on another page.

At Fitzgerald the loss from Brown Rot seems to have been extremely heavy. Thus, Mr. G. E. Whitman reports the following percentages of loss of several varieties of plums: Red June, seventy-five; Ogon, seventy-five; Burbank, ninety-eight; Satsuma, ninety-eight; Abundance, seventy. Of peaches the following percentages of loss are also reported: Alexander, fifty; Triumph, ninety; Elbertas, seventy-five; Fleitas St. John, seventy-five; Tillotson, eighty-five; Amelia, the Early and Late Crawfords, Crosby, Wager, Heath Cling, Chinese Cling, Belle and Mountain Rose, each one hundred.

From Cairo, Mr. J. B. Wight reports about fifty per cent. loss of peaches and sixty per cent. loss of plums. Of the peaches, Triumph rotted worst, and of the plums, Burbank and Gold.

At Pine City, according to Mr. J. W. Shanley, the Elberta, Dr. Berckmans and Reeve's Favorite peaches were practically free from rot Alexander, Old Mixon Free, Stump, Robert E. Lee and Picquett's Late rotted considerably, while Triumph and Thurber suffered much more severely.

Mr. G. H. Miller, of Rome, states that early peaches, such as Sneed, Triumph and Early Rivers, rotted probably fifty per cent. of the crop. Elbertas, Emmas, and other later varieties, were practically exempt. On the whole, Mr. Miller thinks that ten per cent. would probably represent the amount of rot.

From Adairsville, Mr. G. R. Casey reports the average loss at twenty-five per cent.

In Laurens and Twiggs counties the fruit from two extensive orchards was practically all lost. Thus, Col. Jno. M. Stubb's expected shipment of forty-five cars was reduced to five, and these failed to reach market in condition to bring profitable returns.

It is unnecessary to further consider the losses from Brown Rot in different parts of the State. Taken as a whole, and including the loss of fruit enroute to market, the average loss in commercial orchards for the State would probably not be less than forty per cent. On the

basis of a 3,000 car crop, this would mean a loss to Georgia orchardists of from $500,000 to $700,000.

The present epidemic of Brown Rot in Georgia but bears out its previous history of destructiveness in other parts of the United States, when suitable weather conditions prevail for its rapid development and spread. Thus, in the Delaware and Chesapeake peninsular, in 1888, according to Dr. E. F. Smith, fully 800,000 baskets of peaches were lost, and in the spring following, warm rains coming during the blooming time of the peach trees, a general infection of the bloom, from the over-wintering mummies, resulted in a shortening of the crop fully 500,000 baskets. During 1893, according to Smith, in eastern Delaware and Maryland it rained every few days during the peach season, and was frequently warm and cloudy between showers. In consequence, the Brown Rot, due to *Monilia*, was unusually prevalent. From Michigan it is reported by Prof. L. R. Taft that during some

FIGURE 2.

Photomicrograph of small portion of spore-tuft of Brown Rot fungus, showing spore chains, and the manner of development of spores. Much enlarged.

seasons a large part of the peaches, plums and cherries are destroyed, and Prof. H. Garman has reported the fungus as causing a serious rotting of apples in Kentucky. In Oregon, according to Prof. A. B. Cordley, the fungus was the cause of serious rotting of plums in 1897, and to a less extent in 1898. Generally speaking, there is probably no more serious fungus enemy to stone-fruits, and the loss occasioned throughout the country at large must be very great.

DISTRIBUTION AND ECONOMIC HISTORY.

Monilia fructigena is reported by Saccardo[1], from Germany, France, Italy, Great Britain, Belgium, Austria and the United States. In Europe the fungus has been known for many years, and was for a long time considered as a saprophyte. Probably von Thumen[2] and Hallier[3] were first to regard it as of economic importance, and Thumen[4] later more fully considered the evidence as to its being the cause of disease. The same writer, somewhat more than twenty years ago, considered it the most noxious and widely distributed of the diseases of fruits. From the more recent European literature, the disease does not appear to be considered as the cause of such serious loss as formerly. Thus the principal hand-books on plant diseases give it but brief, if any, mention. Sorauer[5] simply mentions the fungus, while Prillieux[6] and Frank[7] give rather full discussions, but do not indicate its seriousness in Europe. Tubeuf and Smith[8] speak of the disease as common in Great Britain and the United States.

In the United States, the disease was first described in 1881, By Dr. C. H. Peck[9], and in 1884 by Dr. J. C. Arthur[10]. Since 1884 it has received considerable attention at the hands of different investigators, notably by Professors Galloway[11], Smith[12], Humphries[13], and Chester[14], whereby our knowledge of its life history and injurious character has been largely increased.

1. Sylloge Fungorum, Vol. IV., p. 34.
2. Oesterr. landw. Wochenbl., 1875, N. 41, p. 484.
3. Wiener Obst. u. Gart. Zeit., 1876, p. 117.
4. Fungi Pomicoli, 1879, p. 22.
5. Pflanzen-Krankheiten, 1886
6. Maladies des Plantes, 1897, Tom. II., p. 449.
7. Krankheiten der Pflanzen, 1896, Bd. 2., p. 360,
8. Diseases of Plants Induced by Cryptogamic Parasites, 1897, p. 497 also, see p. 261.
9. 34th Rept. N. Y. St. Museum, p. 35.
10. 4th Rept. N. Y. Agric. Exp. Station, p. 254.
11. Rept. Secy. Agric.—U. S. D. A., 1888, p. 349.
12. Jn. Mycol., Vol. VII., p. 36
13. Bot. Gazette, (1893), Vol. XVIII., p. 85. See also 8th Ann. Rept. Mass. Agric. Exp. Station, p. 213.
14. Bulletins XIX,, XXIX., and XXXIV., Del. Agric. Exp. Station.

HOST PLANTS.

In the United States, Brown Rot is particularly destructive to the stone fruits, such as peaches, plums and cherries; pomaceous fruits, as apples, pears and quinces, are also subject to attack, but on these fruits the loss is much less. In Europe, according to Frank[15], the fungus occurs on plums, cherries, apricots, peaches, apples and pears.

THE APPEARANCE OF BROWN ROT.

The name, Brown Rot, used throughout this bulletin, is but one of several names by which the disease is known. In literature it has been variously referred to as peach rot, plum fruit rot, brown rot, brown rot of stone fruits, fruit rot, ripe rot of plums, blight, and others. Most Georgia fruit growers probably know the disease under the name of Brown Rot of peaches and plums, and as this name is quite suggestive of the disease, it is here adopted. Though occurring on several different host plants, and affecting not only the fruit but the flowers and twigs, the parasite is in all cases the same.

The Disease on the Flowers.—Under favorable weather conditions, during the blooming period, the disease may make its appearance on the flowers, or even after the petals have fallen. A slight discoloration appears on some part, which soon spreads, involving the entire flower, giving it a brownish, withered appearance. A case in point is reported[16] by Prof. F. S. Earle. During the spring of 1897, in Middle Alabama, there was almost a continuous fog, with unseasonably warm, drizzling rains during the blooming period of the peach. This resulted in the development of myriads of spores from the mummied fruit hanging on the trees, which found their way to the flowers, and a general infection was the result, practically destroying the crop. Extensive injury to flowers and twigs is reported by Dr. Smith[17] from Maryland, in 1891. A flower destroyed by the disease usually remains attached to its pedicel for some time. Later, if the weather becomes rainy, crops of spores are produced, until it may finally fall as a rotten mass, perchance on the leaves or fruit, where, owing to its contagious character, it readily starts the disease.

Blighting of the Twigs.—In the peach, particularly, the fungus does not necessarily stop its growth in the flowers, but the mycelium may grow down through the flower stalks and attack the tissues of the twigs. This same occurrence may take place from infested fruit, and

15. Loc. cit.
16. Proc. Ga. State Hort. Society, 1897, p. 26.
17. Loc. cit.

the blighting of twigs the present summer in Georgia was largely due to this method of infection. This blighting of the peach twigs was so extensive in many orchards as to produce a brown and scalded appearance, much as results from a severe attack of pear blight in pear orchards. The blighting may be due either to the direct action of the fungus on the entire twig, or a girdling may occur at a point some distance down the twig, causing the death, by starvation, of the uninfested distal portion. Where a twig bears but one or two peaches the injury is likely to be confined mostly to near the attachment of the fruit, and girdling may result. Where a number of infested peaches occur along a twig, and at different places on the circumference, the twig is more likely to be killed by the direct effect of the fungus.

So far as the writer has observed, the blighting of peach twigs this year, in Georgia, has been in all cases associated with infested fruit, the mycelium evidently having passed from the fruit, where the infection occurred, into the twig. Although there was abundant growth of tender wood and leaves, nothing was observed to indicate that the fungus had gained entrance through these parts. In a few instances attempts were made to infest the tender growth of twigs and leaves of an Alexander peach tree by rubbing these parts with a moldy fruit, but in no case did infection occur. Spores inserted under the bark of peach twigs soon developed the twig blight. Although it has been stated in the literature of this disease that infection may occur through the tender growth, such infection from spores is probably not common. Concerning the severe twig blighting of the peach in Maryland, in 1891, Dr. Smith[18] found, after an examination of hundreds of blighted twigs, that in every instance such injury was always found associated with blighted and persistent flowers.

The more exact character of the injury to the twigs has been investigated by Dr. Smith[19]. He states: "Carefully made cross sections of freshly blighted twigs were submitted to microscopic examination. The cambium and soft bast cylinders had disappeared almost completely with the formation of extensive gum pockets. These pockets were full of the active mycelium of *Monilia*. This also penetrated into the cortical parenchyma to some extent, and to a lesser degree into the xylem. Practically speaking, the wood and pith and all of the cylinders exterior to the bast were intact. On magnified cross sections a zone of coloration was visible between the wood and bark.

18. Loc. cit.
19. Loc. cit.

On magnification this was found to consist of a gum cavity containing mycelium and fragments of tissue, and bordered by irregular dark zones, the one within composed of young wood and vessels laid down this spring, and the one without composed of remnants of soft bast and phlœm rays. The bundles of bast fibre were also changed from a glistening white to a dirty, yellowish brown."

Rotting of the Fruit.

To fruit growers this disease is best known in connection with rotting of the fruit, and the loss inflicted in this way undoubtedly constitutes the greater part of its injury. The appearance of the disease may vary in minor respects, depending on the fruit infested. On a peach (see Figure 1) the first indication of infection is a small, more or less circular brown spot. This rapidly enlarges, and soon small, whitish tufts of spore-bearing thread may begin to appear on the surface, at first rather sparingly, but in the course of a day or so the original rotten area may become quite covered with the characteristic ash-grey mold. In a short while, from infection, a peach may become quite rotten, brownish and more or less shrunken, either falling to the ground or eventually shriveling up on the tree.

In plums, the indications of infection may not be so evident and the fruit may be infested with the mycelium and show but slight, if any, indications that such is the case. Sooner or later, however, usually as the fruit begins to ripen, the ash-grey spore tufts appear on the surface, though usually not so densely as in the case of the peach. The fruit may either fall to the ground or remain as mummies on the trees. Plums gathered in the evening, apparently sound, have been observed to have developed a few conidial tufts by the next morning. This difficulty of distinguishing infested from sound fruit has frequently caused serious loss to the shipper. Fruit gathered in the evening for morning shipment may prove to be so generally infested as to render them valuless, except for immediate use. An infested plum, though not showing any marked indication, when cut open

FIGURE 3.

A germinating spore of *Monilia fructigena*. Greatly enlarged.

usually shows a more or less brownish or rotten appearance. If such tissue be examined microscopically, the threads of the fungus may be readily detected.

It has been a frequent experience, particularly this year in Georgia, that peaches, although carefully gathered and sorted, may, during the course of a few hours, become quite generally "spotted" from the attack of this fungus. This is particularly likely to happen if, through force of circumstances, it is necessary to gather the fruit while it is wet, as after a rain. Under these circumstances, the spores which may be on the fruit readily germinate, and the germ-tubes, penetrating into the ripening fruit, are soon able to produce perceptible brown spots. In other cases, it is likely that the fruit, when gathered, may be more or less infested, though hardly distinguishable at time of gathering or sorting. Owing to the more rapid ripening processes of the gathered fruit, the fungus develops with great rapidity, producing during the course of a night, rotten, brown spots of considerable size.

The frequent rotting of peaches this year enroute to market must be attributed largely to the Brown Rot fungus. The peaches leave the orchards more or less generally infested with the spores which, during transit, develop the disease. This is particularly likely to occur if the refrigeration is not properly attended to, and if the shipment is consigned to some of the more distant markets.

KEEPING QUALITIES OF PEACHES ENHANCED BY SPRAYING.

It is well to mention in this connection that where fruit has been properly sprayed, to prevent rotting in the orchards, that such fruit has invariably been remarkably free from rot enroute to market. Where the disease has been kept in check, the fruit being practically free from the spores of disease, the rotting, under ordinarily favorable conditions of transit, is inconsequential. This has been the experience of orchardists who sprayed this year. To more definitely illustrate this point, the results of the folowing tests are given, as taken from my note-book: July 5, a basket of apparently perfectly sound peaches was gathered from each of two trees of Heusted's No. 53, one tree having received two applications of Bordeaux Mixture, the other tree being unsprayed. These two baskets were placed side by side on a shelf in the laboratory. Forty-one hours later it was determined by count that three-fourths of the peaches from the unsprayed tree were more or less rotten, while the fruit from the sprayed tree was perfect. July 9, all of the peaches from the unsprayed tree quite rotten and

sprayed fruit perfect. July 10, sprayed peaches still perfect. July 14, find by count that approximately fifty per cent. of fruit from sprayed tree are now rotting, but apparently due to other causes than the Brown Rot. Rest of fruit is drying up, with no signs of rot. Again, on same date, July 5, a basket of Carman peaches was gathered from each of a sprayed and unsprayed tree. July 7, about fifty per cent. of peaches from unsprayed tree rotting, while fruit from sprayed tree perfect. July 10, all peaches from unsprayed tree are quite rotten, and sprayed fruit with three peaches showing rot. July 12, peaches from sprayed trees now rather badly rotten. Practically the same test of keeping qualities of fruit from sprayed and unsprayed trees was made with Early Michigan, Champion, Heusted's Extra Early (No. 16), and Heusted's No. 54, with the result that peaches from sprayed trees have kept from three to five days longer than peaches from unsprayed trees.

SUSCEPTIBILITY OF DIFFERENT VARIETIES.

Considerable variation was noticed in the amount of rot in the different varieties grown at the Station. While probably all varieties will rot more or less, yet the fact that certain varieties had less of rot than others, under the same conditions, is suggestive that the susceptibility of varieties may vary. Of the peaches, Carman, Waddell, Greensboro, Early Crawford, Lady Ingold and Mamie Ross had least of rot; Alexander, Admiral Dewey, Triumph, Early Michigan, Hale's Early, Bishop, Champion, Thurber, Belle and others were more severely attacked. Those varieties densely covered with down, as Alexander, Triumph, Admiral Dewey, Michigan and Hill's Chili were practically destroyed and the idea is suggested that there may be some relation between the amount of down on a peach and its susceptibility to rot.

Of native plums the Americana group, as a whole, proved to be extremely susceptible to the disease this year. Of the twenty varieties growing at the Station, the fruit all rotted, with the partial exception of Hansom. Varieties of the Miner group, as Clinton, Forest Rose, Indian Red, Miner, Nebraska and Prairie Flower, were practically free from rot. Fruit of these varieties is comparatively firm and thick skinned, which may have some bearing on the question of their immunity. In the Wild Goose type there was probably not more than ten per cent. of rot. Some varieties under observation were Wild Goose, Munson (?), Roulette, Beauty, Hughes, Robinson, Ohio Prolific and Pattowattomie. Varieties of *Prunus pumula,* as Heideman's

Red, Black and Yellow, lost practically all of their fruit, and in the case of Heideman's Red the twigs were badly killed. Japanese plums, as a group, seem to be quite susceptible to Brown Rot—particularly later varieties. In many localities however, this year, such early varieties as Red Nagate, Botan and Burbank were practically destroyed.

THE BROWN ROT FUNGUS.

Synonomy.—More recently this plant has been known to mycologists as *Monilia fructigena,* but as is the case with many other fungi, it has received several different names at the hands of botanists. First described, in 1796, by Persoon, as *Torula fructigena,* it has been variously referred to as *Oidium laxum* Ehr.; *Oidium Wallrothii* Thum.; *Acrasporium fructigenum* Pers.; *Oidium fructigenum* Lk.; and *Oospora fructigena* Waltr. Persoon himself finally referred the fungus to the genus *Monilia.*

Relationships.—Owing to the absence of character necessary to definitely classify this plant in some of the well marked groups, Saccardo[20] has placed it among the Fungi Imperfecti, in his Mucedineæ amerasporæ. The same arrangement is followed by Tubeuf and Smith[21] and Massee[22]. Frank[23] associates it with the Pyrenomycetes, and Prillieux[24] regards it as a Discomycete, and says we may regard this parasite as a *Peziza* reduced to its imperfect form of fructification. Tubeuf and Smith[25] state in connection with a consideration of the Discomyceteous genus *Sclerotinia*, that *Monilia fructigena* of the apple, pear, quince, plum, peach, etc., is in all likelihood a form of some *Sclerotinia*, although the ascus form is still unknown. In his studies of this fungus, Humphries[26] has observed two structures not previously reported, one of which he regards as ground for considering it as belonging to *Sclerotinia.* Thus, on mummied peaches placed in moist chamber, which had failed to develop the usual tufts of spore chains, it was found that the mycelium of the fungus had given rise to immense numbers of closely set, flask-shaped sterigmata, each of which produced at its outer end small, globular spores about three microns* in diameter. These are apparently produced in chains after the manner of *Aspergillus* spores. When

20. Loc. cit.
21. Loc. cit.
22. A Text Book of Plant Diseases, p. 300.
23. Loc. cit.
24. Loc. cit.
25. Loc. cit., p. 261.
26. Loc. cit.

*A micron is equal approximately to the $\frac{1}{25000}$ of an inch.

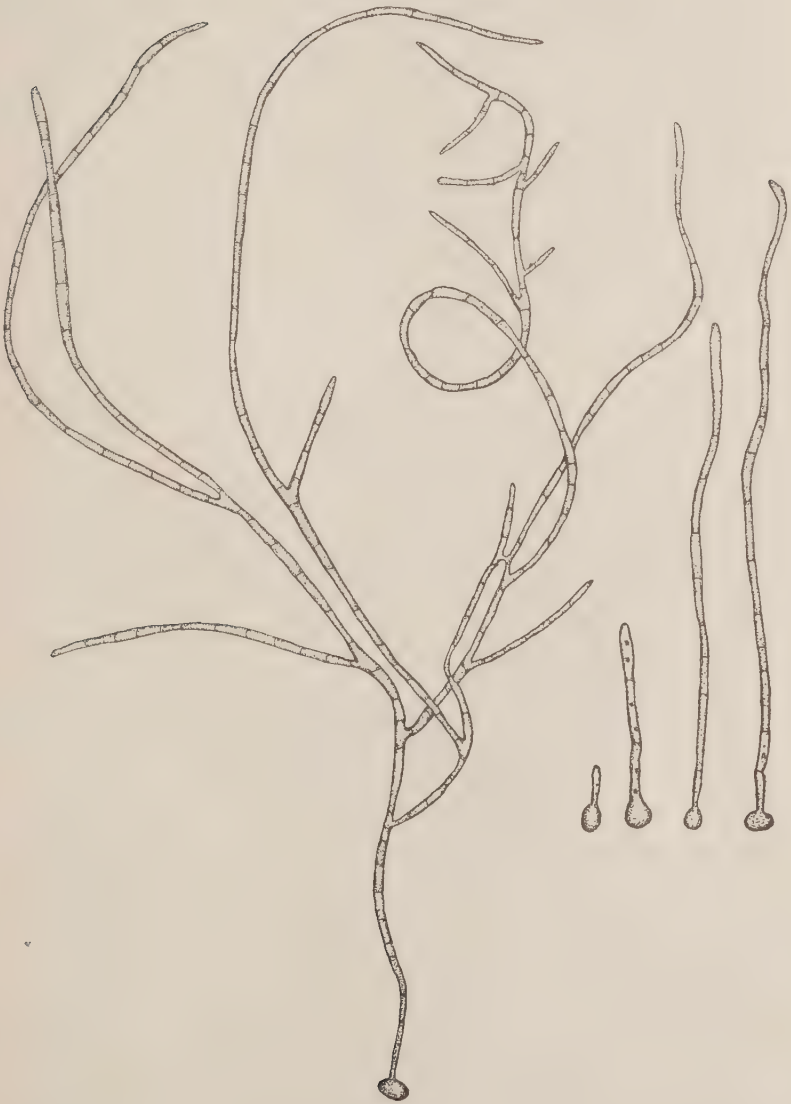

FIGURE 4.

Showing rate of development of Brown Rot fungus. Much enlarged. (See text.)

sown on nutrient gelatine, these spores, after first swelling to double their size, germinated, producing abundant mycelium from which developed the typical monilia spore chains. Also, spores developed in gelatine culture, in their germination produced, instead of the usual hyphæ, a single germ-tube, or very rarely two, which became divided up by transverse septa. Either from one or all of these germ-tube cells, one or two flask-shaped outgrowths developed, from the top of the neck of which in each case globular spores were produced from two and one-half to three microns in diameter, of which not more than one was observed attached. These spores were also found fallen and had begun to germinate. This kind of spore formation is regarded as constituting a true conidial fructification, evidently homologising with that observed by various workers in *Peziza* (*Sclerotinia*) *tuberosa, P. bolaris, Duriæuana, Libertiana* and *Sclerotinia Fuckliana.* Woronin[27] has found in his study of several species of *Sclerotinia*, found on the fruit and leaves of European Vacciniums, a chlamydosporic stage of *Sclerotinia vaccinii* so closely resembling that of *Monilia fructigena* in its mode of growth and spore formation that he has suggested a near relationship. This seems further probable from the observations of Humphries on the occurrence in *Monilia fructigena* of microconidia, structures common to certain *Sclerotinia* and related genera.

Humphries concludes that we may feel justified in the belief that in *Monilia fructigena* we have the persistent chlamydosporic and microconidial stages of a *Sclerotinia* allied to *S. Vaccinii* whose perfect stage has become practically or entirely suppressed.

*The Spore.** – Throughout the summer and growing season generally the Brown Rot fungus is propagated by myriads of spores, formed on the ends of hyphal threads which push their way to the surface of the fruit. These small bodies are developed in bead-like chains which collectively make up the ash-grey tufts of "mold" seen on the surface of infested fruits. The mode of spore formation may be more readily understood by reference to Figure 2. This is a reproduction of a photomicrograph of a very small portion of one of the spore tufts taken from the surface of a peach. As may appear in the figure, the spores are not formed by successive fission from the ends of the hyphal threads, but their development proceeds in a distal direction, the end

27. Ber. d. Deut. Botan. Gesellsch., III., p. LIX., 1885. Also Mem. Acad. Sci. St. Petersburg, VII., XXXVI., No. 6, 1888.

* Strictly speaking, these are probably to be regarded as Conidia.

spore being the youngest. In the formation of branches, a cell broadens at its distal end, thus forming two angles, from each of which a spore chain may develop. Owing to the indeterminate mode of development of a spore chain, its length is not limited, but usually after the chain has grown to a greater or less length the individual joints mature and the resulting spores may soon become more or less separated. Under the influence of warmth and moisture these spores may germinate readily, and if lying on the surface of a peach, plum or similar fruit, the germ-tube pushes through the skin down into the tissues, where there soon develops an extensive, much-branched, growth forming collectively the mycelium. It is the action of this mycelium, during the course of its growth, that brings about the rotting of the fruit.

FIGURE 5.
Photomicrograph of spores of the Brown Rot fungus.
Much enlarged.

As has been elsewhere mentioned, the development of the fungus is quite rapid. Spores may germinate while still attached in the spore-chain, as the writer has frequently observed, and no resting period seems to be required. The germ-tube rapidly lengthens, with the formation of occasional cross partitions dividing the thread into numerous cells. In Figure 4 the rate of growth of the germ-tube from the

spore is shown. On October 12, at 12 M., a few spores were placed in a slide-cell, in sterile peach juice, and the rate of growth was observed under the microscope. The smallest figure, at the left of the four, illustrates the length of the germ-tube five hours later: the next figure to the right shows the length of growth at nine P.M.; in the next figure the growth is shown as it appeared at seven o'clock the following morning, and the last figure to the right shows the length at 12 M., or twenty-four hours from time the culture was started. The larger, much-branched figure illustrates the resulting growth from a single spore in distilled water.

Spores inserted under the skin of a ripening peach with a needle point developed the usual brown rotten spot, an inch or more in diameter, in twenty hours, and the production of spore tufts followed three hours later, thus making the period of reproduction from the spore, under very favorable conditions, at twenty-three hours.

The spores are mostly oval in shape, almost colorless, and with granular contents. In size they may vary from twenty-four to fourteen by twelve to nine microns. By referring to Figure 5 an idea of the spores may be obtained. This is a reproduction of a photomicrograph of spores, collected on a needle point from a "moldy" peach.

FIGURE 6.
Showing fusion of germ filaments, with themselves, and with the spores. Greatly enlarged.

The vitality of these summer spores is a matter of considerable interest and has a practical bearing on the subject of treatment. On account of their delicate structure it has been thought that these would hardly be able to carry the fungus over winter. But their vitality seems to be greater than has been supposed. Thus Galloway states[28]

28. Rept. Secr'y Agric., 1888, p. 349.

that spores are capable of retaining their vitality for a long time. Specimens collected in July of 1886 furnished spores which germinated in May of 1888. Spores from cherries which had hung on the trees for a year germinated readily in moist air, and, when sown upon the young leaves and flowers, soon developed to such an extent as to produce the characteristic discolorations. Smith[29] states that roll cultures from dry material a year old gave results, though only a portion of the conidia germinated. He further states that it is probable that these spores alone are sufficient to tide the fungus over winter. Cordley[30] states that spores kept in a perfectly dry place for nearly two years had lost their power to germinate, though without undergoing any alteration in appearance.

The Mycelium.—The mycelium of the Brown Rot fungus traverses the infested parts in all directions, absorbing the juices of its host, bringing about in fruits the changes designated as Brown Rot. It is

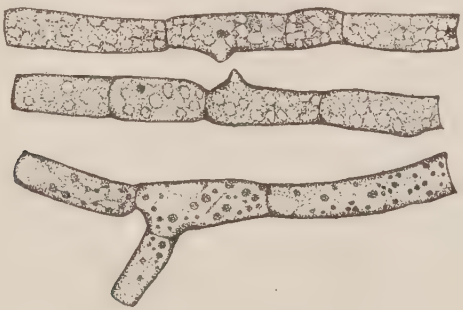

FIGURE 7.
Portions of three hyphae of Brown Rot fungus.
Gaeatly enlarged. (See text.)

the function of the mycelium to secure food for the growth of the fungus and for the development of spores by which its increase is brought about. The relation of the active mycelium to the spores is somewhat analagous to the relation existing between the roots, stem and leaves of a higher plant to its seed. The one part is vegetative, the other reproductive. In structure the mycelium, as found in peaches and plums, is thin walled, septate, of varying diameter, and contains numerous vacuoles. In older hyphæ, these vacuoles may mostly disappear and the contents become more or less granular. See Figure 7. The cells

29. Loc. cit.
30. Bull. 57, Oregon Agric. Exp. Station.

on the left illustrating the granular structure in an older hypa. The two figures to the right showing the vacuolar structure of active hyphæ.

In the dried up fruit, hanging on the trees, or on the ground, the mycelium assumes a dormant condition during the winter, and under suitable conditions in the spring develops an enormous amount of the ordinary summer spores. According to Humphries, there may also be developed from the mycelium in the mummied fruit definite resting cells or "gemmæ," thus further insuring the survival of the plant during the winter. The writer has observed, in cell cultures, the transformation of hypal threads into chains of more or less rounded highly granular cells, which in some cases have become entirely separated from each other. These cells may represent a resting stage of the fungus. As has been stated, there is evidence that the summer spores may carry the fungus over the winter, but its survival is certainly insured by the resting mycelium and gemmæ in the mummied fruit.

BROWN ROT IN THE ORCHARDS.

There is, every fruit year, more or less of rotting of fruit. During ordinary seasons, early varieties are likely to suffer but little; in later varieties, on account of the increasing amount of the spores and more rain, the rotting may be greater. In the absence of sufficient moisture, the great majority of spores fail to germinate, but if a spore should find its way into a crack or wound of a fruit the moist surface would favor germination and the fruit might thus become infected. The wounds made by the curculio and other insects may furnish a point of infection, and those orchards most free from curculio will, during ordinary seasons, be much freer from rot. Where fruit has not been properly thinned, but hangs in more or less of contact, the rotting is likely to be worse. For not only will the disease pass from one fruit to another, where in contact, but moisture is more likely to persist, thus favoring the germination of the spores that might be on the fruit.

In the gathering of fruit for shipment, a general scattering of the spores frequently occurs. Moldy fruit is disturbed and the dried spores become scattered in the air, some of which must fall on the sound fruit. Spores are also distributed by the hands of the picker, particularly if an occasional rotten fruit is gathered by mistake. The hands become more or less infested, and in picking a sound fruit some spores may be left on it which in the crate or car may develop the rot. It is evident therefore that orchards should be as free as possible from

moldy fruit before picking begins. Some of our largest orchardists have made it a practice to regularly collect and destroy the rotten fruit with gratifying results.

WHERE THE WINTER IS PASSED.

Although there is evidence that the summer spores may survive the winter, yet, in the light of our present knowledge, the shrivelled-up fruit or "mummies" on the trees or ground must be regarded as the principal source of infection in the spring. See Figure 8. The general prevalence of the Brown Rot this year has produced an unusual amount of these mummies, and care should be taken, therefore, that the shrivelled-up fruit on the trees and ground be destroyed. If the fruit on the ground be raked out from under the trees, where it may be plowed under, this would probably dispose of them satisfactorily. Pruning out the blighted fruit spurs and twigs would render the work more complete, as the fungus is capable of developing the spore tufts from these parts.

SPRAYING FOR BROWN ROT.

As has been shown, the blighting of the bloom and twigs is not due to the effects of frost or extreme heat, as some have supposed, nor is the rotting of the fruit caused directly by the action of rains or damp, cloudy weather. The cause of these troubles is one and the same, and these conditions of the weather simply furnish favorable conditions for the rapid development and spread of the disease. This being true, the question of preventing injury depends upon the employment of some method or methods which will keep the fungus in check. For this purpose nothing has been found of more value than spraying the trees and fruit with Bordeaux Mixture.

Fortunately for the purposes of illustration the experience of several orchardists with Bordeaux Mixture, this year, may here be given as detailed to the writer by them.

Mr. S. H. Rumph, of Marshallville, whose orchard comprises 140,000 bearing trees, both peach and plum, sprayed his entire orchard, save one block of 20,000 trees, as follows:

(1). Before the blossom opened.

(2). Shortly after the petals had fallen.

(3). About two weeks later.

In addition to these three applications of Bordeaux Mixture, the varieties of peaches, Emma and Salway, both late, received each two more applications as follows:

FIGURE 8.

Mummied peaches, in which the Brown Rot fungus passes the winter.

(4). About May 15.

(5). About June 1.

Mr. Rumph states that where sprayed his fruit was practically free from rot, except along one side of a block of Elbertas, where, just across a road, stood a neighbor's orchard which had not been sprayed, and in which the fruit was rotting badly. This strip of infested fruit, in Mr. Rumph's orchard, did not extend more than one hundred yards inward from the road, and the rotting became less and less from the road inwards.

In the block of 20,000 trees, which were not sprayed, the amount of rot was estimated at from twenty-five to fifty per cent., depending on the variety. This unsprayed block may be fairly regarded as a check and as indicating, approximately, the amount of rot which would have occurred had no spraying been done. The formula used by Mr. Rumph has been three pounds of copper sulfate, eight pounds of lime and fifty gallons of water. To this was added two ounces of Paris green. A no less important result of this spraying has been the excellent condition in which his fruit arrived on the market. Mr. Rumph's results with Bordeaux Mixture have been very satisfactory indeed and clearly show that it is quite practicable to control the Brown Rot even in our largest commercial orchards.

Mr. E. J. Willingham, another extensive orchardist of Marshallville, used the three-six-fifty formula of Bordeaux Mixture with highly favorable results. The first application was made before the bloom opened; the second soon after the petals had fallen and three or four more applications were made, the dates of which could not be furnished. Mr. Willingham states that his fruit was practically free from rot, and arrived on the markets in splendid shape.

Major G. M. Ryals, whose orchard is at Ty-Ty, used Bordeaux Mixture of the three-six-fifty formula. Three applications were made, as follows:

(1). When the fruit had become well set.

(2). When fruit was about one-third grown.

(3). When fruit was about two-thirds grown.

Major Ryals states that his fruit was quite free from rot. Fortunately, from an experimentor's standpoint, a few rows of trees in Major Ryal's orchard were not sprayed, having been overlooked. The fruit on these trees was entirely lost, which may be considered as an index to the severity of the rot in that locality and as further illustrating, by comparison, the value of spraying.

Mr. J. D. Howard, of Lorane (Mims), made but two applications of Bordeaux, using the three-six-fifty formula. These were made:

(1). As buds were swelling.

(2). When fruit was size of small marble.

Mr. Howard estimates the amount of rot on the different varieties as follows: Elberta, three to five per cent.; Crawford, thirty per cent.; Tillotson, five per cent.; Early Rivers, practically none; Alexander, twenty-five per cent.; Family Favorite, thirty per cent.

The results from some varieties are far from satisfactory, and, as Mr. Howard himself states, there should have been at least one or two more applications of Bordeaux.

The results of a limited test of spraying for Brown Rot as conducted at the Station, are given in Table III. There being no orchard available comprising one variety, it was not possible to follow out an extensive scheme to determine the relative value of different numbers of applications. In the experiments reported in the following table, it was necessary to use the variety-test orchard, which contains but three trees of any one variety. The middle tree of a variety was sprayed, and one of the other two considered as a check. In determining the per cent. of rotten fruit from a sprayed and unsprayed tree the peaches were gathered when judged to be sufficiently ripe for market shipment, carefully sorted and counted. The percentages indicated may, therefore, be considered as fairly accurate. In considering the results, it should be remembered that the amount of rot in the sprayed trees was no doubt considerably increased from the fact that the rotting fruit on the closely adjacent, unsprayed trees served as a constant source of infection. Where an entire orchard is sprayed, the amount of rot will certainly be less.

TABLE No. III.

SPRAYING EXPERIMENTS ON THE BROWN ROT ON PEACHES—1900.

VARIETY.	Treatment—with Dates.							Date of ripening.	Per cent. of rotten fruit on unsprayed tree.	Per cent. of rotten fruit on sprayed tree.	Per cent. of fruit saved by spraying.
	May 11. Bordeaux Mixture 4-5-100.	June 5. Bordeaux Mixture 4-5-100.	June 20. Bordeaux Mixture 4-5-100.	July 10. Bordeaux Mixture 4-5-100.	June 25. Copper Acetate, 4 oz. to 50 gallons water.	July 29 Copper Acetate, 4 oz. to 50 gallons water.					
Heusted's No. 53	"	"						July 8	86 5	42	44.
Heusted's No. 54	"	"	"					" 13	93.	25.	68.
Elberta	"	"	"					" 19	69	22	47.
Chinese Cling	"	"	"					" 18	80.	35.	45.
Chinese Free	"	"	"	"				" 20	81.	28.	53
Champion	"	"			"			" 10	86	32.	54.
Lonoke	"	"	"	"		"		Aug 23	92	10.	82
Hoover's Heath	"	"	"	"		"		Sept. 10	95.	19.	76

No specific conclusions as to the number and time of making applications can be drawn from the above table from the fact that in every case a different variety was under treatment, and the test to have answered these questions should have been begun much earlier. As the matter stands, however, which is sufficient reason for the presentation of the table, the value of spraying, even under the unfavorable conditions mentioned, is clearly shown. The per cent. of fruit saved by spraying ranges from forty-four to eighty-two, with a considerable percentage in favor of five applications, four of Bordeaux Mixture and one of copper acetate.

Through the kindness of Mr. J. D. Howard, the Station will be able to carry out, on his place, an elaborate spraying test on a remarkably even block of four-year-old Elbertas. It is hoped to secure more extensive data in spraying for Brown Rot.

FIGURE 9.
"Shot-hole" effect on peach leaves, of 4-5-100 formula of Bordeaux mixture.

THE PROPER FORMULA FOR BORDEAUX.

One of the serious difficulties that has been in the way of spraying for peach diseases is the extreme sensibility of peach foliage to copper fungicides. In the writer's experiments, reported in Table III., the Bordeaux Mixture was used of the four-five-one hundred formula; that is, four pounds of copper sulfate, five pounds of lime and one hundred gallons of water. Despite previous experience at the Station[31], when the four-five-seventy-five formula did not prove injurious to any extent, the formula used this year, four-five-one hundred, proved to be quite injurious, causing a considerable "shot-holeing" of the leaves and with some varieties an undesirable amount of foliage dropped. Consequently this formula can not be recommended. Prof. W. M. Scott has shown[32], as a result of experiments conducted in the

31. Bull. 42, Ga. Agric. Exp. Station.
32. Proc. 23d Ann. Meeting Ga St. Hort Soc., p. 66.

orchards of Mr. S. H. Rumph and the Hale Georgia Orchard Co., that there is but little if any injury to peach foliage in the use of Bordeaux of the following formula:

Copper sulfate	3 pounds
Quick-lime	6 pounds
Water	50 gallons.

As has been noted, this formula has been used this year by several large orchardists, and it was extensively used around Marshallville in 1898. No injury of any consequence seems to have followed its use, and the question of the proper formula for Bordeaux, under Georgia conditions, seems to have been settled. Whenever it is observed that the foliage is being injured, as shown in Figure 9, the trouble in most cases can be corrected by an increase of lime in the formula.

THE PREPARATION OF BORDEAUX MIXTURE.

At first thought it might seem that a discussion of this topic would be unnecessary, but the use of properly made Bordeaux has an important bearing on the results obtained. Thus it has been found that if a concentrated solution of copper sulfate be added to thick milk of lime, the resulting mixture is strikingly different in chemical composition and physical structure than if the two substances had been brought together in a much more diluted condition. And it is also true that if the copper sulfate solution and milk of lime be poured together when the latter or both are warm different effects result than if the substances had been brought together in a cool condition.

To prepare Bordeaux, on a small scale, for peaches and plums, the following procedure is recommended:

(1). Place twenty-five gallons of water in a barrel, or other suitable wooden vessel, and in this suspend three pounds of copper sulfate, in a gunny sack, so that it will be just below the surface of the water. The bag may be suspended by a stick placed across the barrel, and it will be found that the copper sulfate will quite dissolve over night.

(2). Weigh out six pounds good quick-lime and slack, using great care that a smooth paste, free from grit and small lumps, is obtained. When the lime is slacked, add sufficient water in a barrel to bring it up to twenty-five gallons.

(3). After the copper sulfate is dissolved, and the lime cool, first thoroughly stir the milk of lime and then slowly pour the sulfate and lime together, by buckets, into a barrel holding fifty gallons. To more fully insure the perfect mixture, the Bordeaux should be thoroughly stirred with a broad paddle for three minutes.

For spraying on a large scale much time may be saved in the making of Bordeaux by the preparation of stock solutions of both the copper sulfate and lime. For the stock solution of copper sulfate, procure a barrel that will hold fifty gallons, mark the fifty gallon point, weigh out one hundred pounds of copper sulfate, tie up in a sack and suspend near the top of the barrel. Fill the barrel with water, and in the course of two or three days the copper sulfate will be dissolved, when the sack should be removed and the barrel filled up to the fifty gallon mark. In this solution it is evident that in every gallon of water there are two pounds of copper sulfate. This stock solution may be kept practically an indefinite time and not recrystalize.

The stock lime may be prepared in much the same way as detailed for the copper sulfate. Procure a barrel that will hold fifty gallons and mark the fifty gallon point. Weigh out one hundred pounds of fresh quick-lime and slack thoroughly in the barrel, after which add water to bring it up to the fifty gallon mark. Each gallon of this preparation contains two pounds of lime.

In the preparation of the Bordeaux from the stock sulfate and stock lime, of the three-six-fifty formula, it will be necessary to take one and one-half gallons of the stock sulfate and three gallons of the stock lime to every fifty gallons of water. The stock sulfate and stock lime should each be diluted to twenty-five gallons of water, and then slowly poured together in a fifty gallon barrel as previously described. As a matter of precautiion, it is advisable to keep the stock solutions well covered.

COPPER ACETATE.

This copper compound is recommended for use when it is desired to spray the fruit after coloring has begun, or later.

The danger of staining the fruit, which might follow from applications of Bordeaux Mixture at this time, is thus obviated. There are several acetic acid compounds with copper, but the dibasic acetate of copper is the one used as a fungicide. It should be used at the rate of six ounces to fifty gallons of water. The Copper Acetate is simply added to the water, which should be thoroughly stirred.

HOW MANY TIMES TO SPRAY, AND WHEN.

This very important question, from a practical standpoint, can not be considered as yet settled for Georgia. Further experimentation is necessary before sufficient data will have been secured to warrant spe-

cific advice on this point. The reader has already noted the value of three applications of Bordeaux, as used by Mr. Rumph and Major Ryals, and the value of two as used by Mr. J. D. Howard. The value of five applications, four of Bordeaux and one of copper acetate, has been shown in the table of results obtained at the Experiment Station, but these latter results are not comparable to the former cases cited, since in our work the earlier sprayings were omitted.

As a result of experiments in Delaware, in 1892-'93-'95, Prof. Chester draws the following conclusions:

(1). From five to six applications of an effective fungicide sufficed to produce the best results, provided the first two applications were made before the bloom opened.

(2). Five applications made and begun after the bloom was nearly shed were considerably less effective than when two of these applications were made before the bloom opened.

(3). Four applications made and begun after the fruit had set were less effective than when two of these were made before the bloom opened.

(4). When two applications were made better results were obtained when one of these was applied before the buds opened, and again when the fruit was about one-half size, than when both were made before the bloom opened.

The results from the three years' work clearly show the importance of the early applications in Delaware. These are designed to free the orchard from the spores of the fungus and to protect the bloom. The same writer states as a result of experiments in 1896 that a rational and effective plan for treating peach orchards for rot would be to spray three times; just before the blossoming, after the bloom has entirely fallen, and at the beginning of coloring.

In Georgia, on account of the liability of excessive rains during June or July, it would appear advisable, in the present state of our knowledge, to make at least four sprayings to insure the greatest freedom from rot, and the writer recommends the following calendar:

(1). Spray with Bordeaux Mixture just before blossoming.

(2). Spray with Bordeaux Mixture as soon as bloom has entirely dropped, adding two ounces of Paris green for each fifty gallons of water.

(3). Spray with Bordeaux Mixture ten days or two weeks before time of coloring.

(4). Spray with Copper Acetate when fruit begins to color.

In regions where the peach leaf curl is injurious, the Bordeaux for the first application, i. e., before the bloom opens, should be made up of six pounds of copper sulfate, six pounds lime to fifty gallons of water. A thorough spraying with this strength will practically control this serious affection.

In the control of Brown Rot, it is necessary that the fruit be protected as much as possible with the spray mixture and especial effort should be made to do this. The purpose of the fungicide on the fruit is to prevent the germination and growth of the spores which may fall on its surface, and the thoroughness with which the fruit has been sprayed will largely affect the results. Should the spray mixture be largely washed off, infection of the fruit could readily occur; hence, during rainy weather particularly, about the coloring time of the fruit, when it is quite susceptible, it is desirable to make more frequent applications of the fungicide than outlined in the previous schedule. There is much room for judgment under such conditions, but the effort should be made to keep the fruit protected at all times by a sufficient coating of the fungicide on its surface.

There has been some objection raised to the application of the first spraying, on the ground that a subsequent frost may quite destroy the fruit crop, from which it is argued that this spraying has been thrown away. It is probably true that this spraying, by its general sanitary effect on the trees, is worth much more than its cost. These early sprayings, as appears from the four years' work of the Delaware Station with Brown Rot, are extremely important in the control of the disease, their use giving uniformly better results than when omitted; hence, on the chance of getting a full or partial fruit crop, it would seem wise to make the first application. Spraying for Brown Rot may be properly compared to an insurance of the crop, and the wisdom of insurance in general is now no longer scarcely a debatable question.

The length of time from ripening that Bordeaux may be used without danger of staining the fruit will vary much with the amount and nature of rains that occur. In using the three-six-fifty formula, the fungicide is likely to persist longer than if less lime were used. Mr. S. H. Rumph, who uses the three-eight-fifty formula, considers that a peach, during the course of a month, will so develop as to throw off most if not all trace of the Bordeaux. It would be on the safer side to substitute the Copper Acetate for Bordeaux when spraying within three or four weeks of the time of ripening.

THE COST AND BENEFITS OF SPRAYING.

Copper sulfate is quoted in barrel lots (New York, Sept. 19) at seven cents per pound. First grade quick-lime, per barrel of two hundred pounds, should not cost more than $1.00, or one-half cent per pound. Based on these prices, one gallon of the three-six-fifty formula Bordeaux would cost for the chemicals mentioned $.048, or slightly less than one-half cent. One gallon of the mixture is sufficient to thoroughly spray an average five or six year old tree. Including the cost of chemicals and labor in the preparation and application of the Bordeaux, it should not exceed one and one-half cents per tree to spray an orchard one time, or four times for six cents.

For the sake of illustration, let us consider that a five or six year old tree should yield at least two crates of first-class peaches, and that these have a net value of seventy-five cents per crate. Suppose that twenty-five per cent. of this fruit was lost from rot, reducing the net value of the fruit from $1.50 to $1.12½. There is thus a loss of thirty-seven and one-half cents per tree. If seventy-five per cent. of this loss could have been reclaimed by spraying, at a total cost of six cents per tree, there would remain, as a net gain in favor of spraying, twenty-two cents per tree. This net gain per tree, calculated for an orchard of 50,000 trees, would mean a clear saving of $11,000.

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